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(54) **Method of storing fruits and vegetables.**

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Description

The present invention relates to an improvement in the method of storing agricultural products such as fruits and/or vegetables immediately after harvest within a storage which maintains controlled atmospheres. More particularly, the present invention is concerned with a method of storing agricultural products in an atmosphere which has a low oxygen level and a high carbon dioxide level and which is slightly subatmospheric.

Storage of fruits and vegatables is very important for enabling the supply to be adjusted in accordance with the daily fluctuation in the demand and for supplying consumers with such products even after the season of harvest.

Hitherto, various storage methods have been proposed and employed, such as controlled atmospheres (CA) storage method and reduced pressure storage method. Briefly, the controlled atmospheres storage method is to store fruits and/or vegetables in an atmosphere which is controlled to maintain a low oxygen content and a high carbon dioxide content, as well as a high relative humidity, and which is held at a temperature generally ranging between 0 °c and 15 °C. More specifically, the storage atmosphere is adjusted to have a gaseous composition containing less than 20% of oxygen and 1 to 10% of carbon dioxide, with the relative himidity maintained at 80% or higher. In general, the gaseous composition is determined to be optimum for the types of the product or products to be stored. Various methods have been proposed for attaining the low oxygen content and high carbon dioxide content of the storage atmosphere. One of such methods relies upon the respiration of the product stored in a storage chamber such that the oxygen is consumed and carbon dioxide is generated as a result of the respiration, so as to establish the controlled atmospheres. This method, however, is disadvantageous in that an impractically long time is required for the establishment of the controlled atmospheres. For instance, it takes 20 to 30 days for controlled atmospheres to be established in a storage chamber storing apples. In another method, the controlled atmospheres are established by making use of a gas which is produced by burning propane gas. This method also is complicated in that the burning of propane gas requires a specific caution to eliminate any danger, and in that an additional system has to be used for the purpose of removing excessive carbon dioxide in the storage chamber.

On the other hand, the reduced pressure storage method, which is disclosed in Japanese Patent Examined Publication No. 57-4298, is intended for long storage of agricultural products by promoting diffusion of ethylene and reducing the partial pressure of oxygen, through reducing the pressure in the storage chamber. In order to promote the diffusion of ethylene while reducing the oxygen partial pressure to a level effective for the long storage of agricultural products, it is necessary that the total pressure in the storage chamber has to be reduced to about 0,13 bar or below. This in turn requires a strong storage chamber designed to be highly resistant to pressure. Such a chamber is generally heavy and, therefore, is not suitable for transportation.

Japanese Patent Unexamined Publication No. 59-88401 discloses a storage method which is a combination of the reduced pressure storage method and the controlled atmospheres storage method. According to this method, the pressure in the storage chamber is reduced so as to lower the partial pressure of oxygen, and a high carbon dioxide level is established by the carbon dioxide which is produced by the metabolism of fruits and vegetables. This method, however, suffers from the same disadvantage as that encountered with the reduced pressure storage method, because the pressure in this storage chamber is maintained between 0,027 and 0,27 bar.

CH-A-416 288 refers to a method of storing fruits and vegetables within a storage chamber under controlled atmosphere, the pressure being slightly higher than the atmospheric pressure. The storage atmosphere is adjusted to have a gaseous composition containing: 1 to 10% O_2, 1 to 15% CO_2, up to 100% rel. humidity and the temperature being comprised between -1.7 and 12.8 °C. According to this method, air, carbone dio ide and nitrogen are continuously supplied into the storage chamber and said gaseous mixture is exhausted from said chamber as the supply proceeds. In order to ventilate the storage chamber the pressure inside the storage chamber must be kept higher than the atmospheric pressure. By this air in the storage chamber is forcibly exhausted to the outside by raising the internal pressure. For this reason, in that environment, ethylene generated inside the vegetables stored therein is hardly exhausted. Further the stored fruits may be damaged by the compression force loaded to the fruits.

FR-A-2 182 080 is concerned with a method of storing fruits and vegetables within a storage chamber under subatmospheric pressure, the air pressure being maintened between about 0,005 and 0,53 bar, its temperature between -2 and 15 °C and its humidity between 80 and 100%. This method is suitable for mobile storage chambers. In this method only a density of O_2 is lowered without controlling CO_2, so that it is necessary to reduce the pressure to a range from 0.1 to 0.2 bar to keep the O_2 density in a range from 2

to 3%. For that reason, when fruits stored in the apparatus, expecially soft oranges are taken out from this storage chamber, damages given to surfaces of the fruits are very severe with a large quantity of moisture evaporated from the surfaces, so that a loss of moisture in the fruits is very high.

US-A-4 685 305 relates to a similar method.

Accordingly, an object of the present invention is to provide an improved method of storing fruits and/or vegetables immediately after harvest within a storage chamber which maintains controlled atmospheres.

The method provided by the present invention is characterized in that the controlled atmospheres maintained in said storage chamber have a total pressure between 0.75 and 0.93 bar (560 and 700 Torr), an oxygen partial pressure of about 0.02 to about 0.19 bar (about 15 to about 145 Torr), a carbon dioxide partial pressure of about 0.02 to about 0.15 bar (about 15 to about 115 Torr), a relative humidity not lower than 90%, and a temperature of about 0 to 15 °C.

In this method, air, carbon dioxide and, as required, nitrogen are continuously supplied into the storage chamber and gases are exhausted from the chamber at rates corresponding to the rates of supply, whereby the total pressure and the oxygen and carbon dioxide partial pressures are maintained in the above-specified ranges.

The above and other objects, features and advantages of the invention will become clear from the following description of the preferred embodiment when the same is read in conjunction with the accompanying drawings.

The attached sole Figure is a flow diagram of an embodiment of the storage method in accordance with the present invention.

In the known controlled atmospheres storage method for storing fruits and vegetables, the interior of the storage chamber is maintained substantially at the same level as the atmospheric pressure. In contrast, in the storage method of the present invention the controlled atmosphere in the storage chamber is maintained at a pressure slightly below the atmospheric pressure (referred to as "slightly subatmospheric pressure"), between 0,75 and 0,93 bar.

The use of the slightly subatmospheric pressure provides an advantage that the requirement for the resistance to pressure of the storage chamber becomes less severe so that the storage chamber can be designed to have a reduced weight, thus facilitating the transportation. Another advantage offered by the use of the subatmospheric pressure is that that ethylene generated from the fruits and vegetables can easily be expelled from the region around the fruits and vegetables, as compared with the known controlled atmospheres storage method. Further it is possible to prevent damages to the fruits and evaporation of moisture which occur in association with increase or reduction of pressure in the known methods according to CH-A-416 288 or FR-A-2 182 080. In the storage method of the present invention, the controlled atmospheres in the storage chamber storing fruits and vegetables, held at the slightly subatmospheric pressure, can be maintained by continuously supplying the storage chamber with air, carbon dioxide and, as required, nitrogen, while exhausting the storage gas from the chamber at a rate corresponding to the rate of supply of the gases mentioned above.

The following Table 1 shows conditions of the controlled atmospheres storage method and temperatures of the controlled atmospheres which are considered by those skilled in the art to be appropriate for the purpose of storing fruits and vegetables.

Table I : Recommended CA conditions for selected fruits and vegetables

Commodity	Temp. range (°C)	CA	
		%O_2	%CO_2
Apple	0 - 5	2 - 3	1 - 2
Apricot	0 - 5	2 - 3	2 - 3
Cherry (sweet)	0 - 5	3 - 10	10 - 12
Fig	0 - 5	5	15
Kiwifruit	0 - 5	2	5
Nectarine	0 - 5	1 - 2	5
Peach	0 - 5	1 - 2	5
Pear	0 - 5	2 - 3	0 - 1
Persimmon	0 - 5	3 - 5	5 - 8
Plum and prune	0 - 5	1 - 2	0 - 5
Strawberry	0 - 5	10	15 - 20
Avocado	5 - 13	2 - 5	3 - 10
Banana	12 - 15	2 - 5	2 - 5
Grapefruit	10 - 15	3 - 10	5 - 10
Lemon	10 - 15	5	0 - 5
Lime	10 - 15	5	0 - 10
Olive	8 - 12	2 - 5	5 - 10
Orange	5 - 10	10	5
Mango	10 - 15	5	5
Papaya	10 - 15	5	10
Pineapple	10 - 15	5	10
Artichokes	0 - 5	2 - 3	3 - 5
Asparagus	0 - 5	air	5 - 10
Beans, snap	5 - 10	2 - 3	5 - 10
Broccoli	0 - 5	1 - 2	5 - 10
Brussels sprouts	0 - 5	1 - 2	5 - 7
Cabbage	0 - 5	3 - 5	5 - 7
Cantaloupes	3 - 7	3 - 5	10 - 15
Cauliflower	0 - 5	2 - 5	2 - 5
Celery	0 - 5	2 - 4	0
Corn, sweet	0 - 5	2 - 4	10 - 20
Cucumbers	8 - 12	3 - 5	0
Honeydews	10 - 12	3 - 5	0
Leeks	0 - 5	1 - 2	3 - 5
Lettuce	0 - 5	2 - 5	0
Mushrooms	0 - 5	air	10 - 15
Onions, green	0 - 5	1 - 2	10 - 20
Peppers, bell	8 - 12	3 - 5	0
Peppers, chili	8 - 12	3 - 5	0
Spinach	0 - 5	air	10 - 20
Tomatoes, partially-ripe	8 - 12	3 - 5	0

As will be understood from Table 1 above, the gaseous compositions of the controlled atmospheres are preferably changed in accordance with the kinds of the fruits and vegetables to be stored. The method of the present invention makes it possible to establish, without requiring any specific device such as a gas burning system, the controlled atmospheres which are optimum for the storage of desired fruits and vegetables and which essentially have low oxygen level and high carbon dioxide level, by continuously

supplying the storage chamber with air, carbon dioxide and, as desired, nitrogen, while exhausting the storage gas from the chamber at a rate corresponding to the rate of supply. For instance, when the storage chamber is designed to withstand a reduced internal pressure of 0,53 bar, the internal pressure of the storage chamber is first reduced to 0,53 bar and then carbon dioxide is introduced into the chamber to raise the internal pressure up to 0,6 bar, so that controlled atmospheres having an oxygen content of about 19% and a carbon dioxide content of about 11% are established within the storage chamber. The initial air in the storage chamber may be partially substituted by nitrogen. By suitably selecting the proportion of the air to be substituted and the amount of carbon dioxide to be charged into the storage chamber, it is possible to obtain any desired carbon dioxide content and oxygen content of the controlled atmospheres within the storage chamber. Once the desired gaseous composition is obtained within the storage chamber, gases from an external air supply source, carbon dioxide supply source and the nitrogen supply source are mixed to form a gaseous mixture of the same composition as that of the atmospheres established in the storage chamber, and the thus formed gaseous mixture is continuously supplied into the storage chamber while the storage gas is continuously exhausted from the storage chamber at a rate corresponding to the rate of supply of the gaseous mixture.

Referring to the sole Figure attached to the specification, a plurality of storage chambers 43a, 43b, ..., 43n are connected to a common vacuum pump 47 through pressure regulating valves 45a, 45b,..., 45n, respectively. The storage chambers 43a, 43b, ..., 43n also are connected to a common atmosphere gas supply source 11 through respective gas-composition/pressure regulating means 21a, 21b,...,21n. The atmosphere gas supply source 11 is composed of an air supply source 13, a carbon dioxide supply source 15 and, as desired, a nitrogen supply source 17, so that air, carbon dioxide and, as desired, nitrogen are supplied to each of the gas-composition/pressure regulating means 21a, 21b,...,21n.

The gas-composition/pressure regulating means 21a is composed of an air pressure controller 23a, an air flow rate controller 25b, a carbon dioxide pressure controller 27a, a carbon dioxide flow rate controller 29a, a nitrogen pressure controller 31a, a nitrogen flow rate controller 33a, and a humidity controller 35a, which cooperate in realizing desired composition and pressure of the gaseous mixture of oxygen, carbon dioxide and nitrogen. The thus formed gaseous mixture having the desired composition and pressure is introduced into the storage chamber 43a after humidification performed by the humidity controller 35a. The water or moisture content to be supplied into the storage chamber is controllable by adjusting the opening degree of the valve 37a provided in a by-pass. According to another method of humidification, vapor is generated by a supersonic oscillator and the thus generated water vapor is made to accompany the gaseous mixture. It will be clear to those skilled in the art that the compositions, as well as levels of pressure and humidity of the gaseous mixtures to be fed to the other storage chambers 43b,...,43n can be controlled in the same manner as that described above, by means of the respective gas-composition/pressure regulating means 21b,..,21n.

A description will be made hereinunder as to a practical case in which controlled atmosphere of the desired conditions is maintained in the storage chamber 43a by using air and carbon dioxide supply sources. As the first step, the storage chamber 43a is evacuated by a vacuum pump 47 until the internal pressure comes down to 0,53 bar, and then carbon dioxide is introduced into the storage chamber until the internal pressure is raised to 0,6 bar. In consequence, an oxygen partial pressure of 0.21 x 0,53 bar and a carbon dioxide partial pressure of 0,067 bar are established in the storage chamber 43a. Thus, controlled storage atmospheres having an oxygen content of about 18.6% and a carbon dioxide content of about 11% are established within the storage chamber. Thereafter, a gaseous mixture having a pressure of 0,6 bar and an oxygen content of about 18.6% and carbon dioxide content of about 11% is formed by suitably operating the pressure gegulator 23a and flow rate regulator 25b for air and the presure regulator 27a and flow rate regulator 29a for carbon dioxide. The thus formed gaseous mixture is continuously supplied into the storage chamber 43a while the gas in this storage chamber is continuously exhausted by the vacuum pump 47 at the rate corresponding to the rate of supply of the gaseous mixture. In consequence, controlled atmospheres of a total pressure of 0,6 bar and having an oxygen content of about 18.6% and a carbon dioxide content of about 11% are always maintained within the storage chamber 43a.

When the storage chamber 43a is designed to have a proof pressure corresponding to an internal pressure of 0,53 bar, while a demand exists for maintaining a total pressure of 0,6 bar within the storage chamber, it is not allowed to reduce the oxygen content to a level below about 18.6% and to increase the carbon dioxide content to a level above about 11%. A further reduction in the oxygen content or a further increase in the carbon dioxide content, however, can be effected without substantial difficulty, by using nitrogen in addition to air and carbon dioxide. For instance, the process of establishing the controlled storage atmospheres may be modified as follows. As the first step, half the amount of air initially residing in the storage chamber 43a is substituted by nitrogen, and then the interior of the storage chamber 43a is

evacuated by the vacuum pump 47 until the internal pressure comes down to 0,53 bar, followed by introduction of carbon dioxide into the chamber until the total pressure in the storage chamber is increased to 0,6 bar. With this method, it is possible to establish controlled storage atmospheres having an oxygen content of about 9% and a carbon dioxide content of about 11% within the storage chamber 43a. Once this condition is established in the storage chamber 43a, a gaseous mixture having a pressure of 0,6 bar and having an oxygen content of about 9% and a carbon dioxide content of about 11% is formed through a suitable control of the pressures and flow rates of air, carbon dioxide and nitrogen, in the same manner as that described before, and the thus formed gaseous mixture is continuously supplied into the storage chamber 43a while the storage gas is exhausted by the vacuum pump 47 from the storage chamber 43a at a rate corresponding to the rate of supply, whereby controlled storage atmospheres having a total pressure of 0,6 bar and oxygen and carbon dioxide contents of about 9% and about 11%, respectively, are maintained within the storage chamber 43a. In an alternative, the total pressure is reduced to 0,6 bar, instead of 0,53 bar, and a gaseous mixture adjusted to have a desired composition is supplied into the storage chamber while the storage gas is exhausted by the vacuum pump from the storage chamber at a rate corresponding to the rate of supply of the gaseous mixture. It will be apparent to those skilled in the art that this alternative offers the same advantage as those derived from the described embodiment.

It will also be clear to those skilled in the art that optimally controlled storage atmospheres of slightly subatmospheric pressure may be established and maintained within the respective storage chambers 43b to 43n, according to the exactly same procedure employed in the case of the storage chamber 43a. In illustrated example, each of the storage chambers has its own gas-composition/pressure regulating means 21a,21b,..,21n and cooler 51a,51b,...,51n, so that the compositions, pressures and temperatures of the storage atmospheres in the respective storage chambers can be optimized for the types and degrees of maturing of products such as fruits and vegetables stored therein, independently of the conditions of other storage chambers.

As will be understood from the foregoing description, the method of the present invention offers the following advantages.

Firstly, the method of the invention enables a prompt expelling of etylene from the region around the stored products as compared with conventional controlled atmospheres storing method under atmospheric pressure, by virtue of the employment of slightly subatmospheric controlled atmospheres, without impairing the advantages of the controlled atmospheres storage method. In addition, the storage chamber is required to withstand only a small force which corresponds to the difference between the atmospheric pressure and the internal pressure which is not lower than about 0,53 bar, so that the requirement for the mechanical strength of the storage chamber becomes less severe. This makes it possible to apply the storage method of the invention not only to stationary storage chambers but also to mobile storage chambers which are intended for transportation of the products. It is also to be pointed out that the storage method of the present invention can be used for the purpose of storage of various foods other than agricultural products such as meats, fishes, grains, as well as storage of flowers and bulbs.

Claims

1. A method of storing fruits and/or vegetables immediately after harvest within a storage chamber which maintains controlled atmospheres, said method characterized in that the controlled atmospheres maintained in said storage chamber have a total pressure between 0.75 and 0.93 bar (560 and 700 Torr), an oxygen partial pressure of about 0,02 to about 0,19 bar (about 15 to about 145 Torr), a carbon dioxide partial pressure of about 0,02 to about 0,15 bar (about 15 to about 115 Torr), a relative humidity not lower than 90%, and a temperature of about 0 to 15 °C.

2. A method according to Claim 1, wherein air and carbon dioxide from external sources are mixed under controlled pressure and flow rates to prepare a gaseous mixture having the same pressure and the same oxygen and carbon dioxide contents as said controlled atmospheres in said storage chamber, and said gaseous mixture is continuously supplied into said storage chamber while the gas balanced with the rate of supply of said gaseous mixture is exhausted from said storage chamber.

3. A method according to Claim 1, wherein air, carbon dioxide and nitrogen from external sources are mixed under controlled pressure and flow rates to prepare a gaseous mixture having the same pressure and the same oxygen and carbon dioxide contents as said controlled atmospheres in said storage chamber, and said gaseous mixture is continuously supplied into said storage chamber while the gas balanced with the rate of supply of said gaseous mixture is exhausted from said storage chamber.

4. A method according to Claim 1, wherein a plurality of said storage chambers are provided, each storage chamber is connected to an external gas supply source common to all the storage chambers through respective gas-composition/pressure regulating means, and further each storage chamber is also communicated with a common vacuum pump through respective pressure regulating valves, whereby the total pressure, oxygen partial pressure, carbon dioxide partial pressure and the relative humidity of said controlled atmospheres in the respective storage chambers are controllable independently of other storage chambers.

Patentansprüche

1. Verfahren zur Lagerung von Früchten und/oder Gemüse sofort nach der Ernte in einer Lagerkammer, die eine geregelte Atmosphäre aufrechterhält, dadurch gekennzeichnet, daß die in der Lagerkammer geregelte und aufrechterhaltene Atmosphäre einen Gesamtdruck zwischen 0,75 und 0.93 bar, einen Sauerstoff-Partialdruck von etwa 0,02 bis etwa 0,19 bar, einen Kohlendioxid-Partialdruck von etwa 0,02 bis 0,15 bar, eine relative Feuchtigkeit nicht weniger als 90 % und eine Temperatur von 0 bis 15 ° C aufweist.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß Luft und Kohlendioxid von äußeren Quellen unter geregelten Druck- und Strömungswerten gemischt werden, um eine Gasmischung zu bereiten, die denselben Druck und dieselben Sauerstoff- und Kohlendioxidgehalte enthält, wie die geregelte Atmosphäre in der Lagerkammer, und daß die Gasmischung kontinuierlich in die Gaskammer eingeleitet wird, während das Gas, welches der Zufuhrmenge der Gasmischung entspricht, aus der Lagerkammer abgesaugt wird.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß Luft, Kohlendioxid und Stickstoff von äußeren Quellen unter geregelten Druck- und Strümungswerten gemischt werden, um eine Gasmischung zu bereiten, die denselben Druck und dieselben Sauerstoff- und Kohlendioxidgehalte enthält, wie die geregelte Atmosphäre in der Lagerkammer, und daß die Gasmischung kontinuierlich in die Gaskammer eingeleitet wird, während das Gas, welches der Zufuhrmenge der Gasmischung entspricht, aus der Lagerkammer abgesaugt wird.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß eine Mehrzahl von Lagerkammern vorgesehen sind, jede Lagerkammer über entsprechende Gas-Zusammensetzungs-/Druckregel-Einrichtungen an eine äußere Gaslieferquelle, die allen Lagerkammern gemeinsam ist, angeschlossen ist, und weiterhin jede Lagerkammer über entsprechende Druckregelventile an eine gemeinsame Vakuumpumpe angeschlossen ist, wodurch der Gesamtdruck, der Sauerstoff-Partialdruck, der Kohlendioxid-Partialdruck und die relative Feuchtigkeit der geregelten Atmosphäre in den entsprechenden Lagerkammern unabhängig von anderen Lagerkammern regelbar sind.

Revendications

1. Procédé pour stocker des fruits et/ou des légumes immédiatement après la récolte à l'intérieur d'une chambre de stockage qui maintient des atmosphères contrôlées, ladite méthode étant caractérisée en ce que les atmosphères contrôlées maintenues dans ladite chambre de stockage ont une pression totale entre 0,75 et 0,93 bar (560 et 700 Torr), une pression partielle en oxygène d'environ 0,02 à environ 0,19 bar (environ 15 à environ 145 Torr), une pression partielle en dioxyde de carbone d'environ 0,02 à environ 0,15 bar (environ 15 à environ 115 Torr), une humidité relative non inférieure à 90 %, et une température d'environ 0 à 15 ° C.

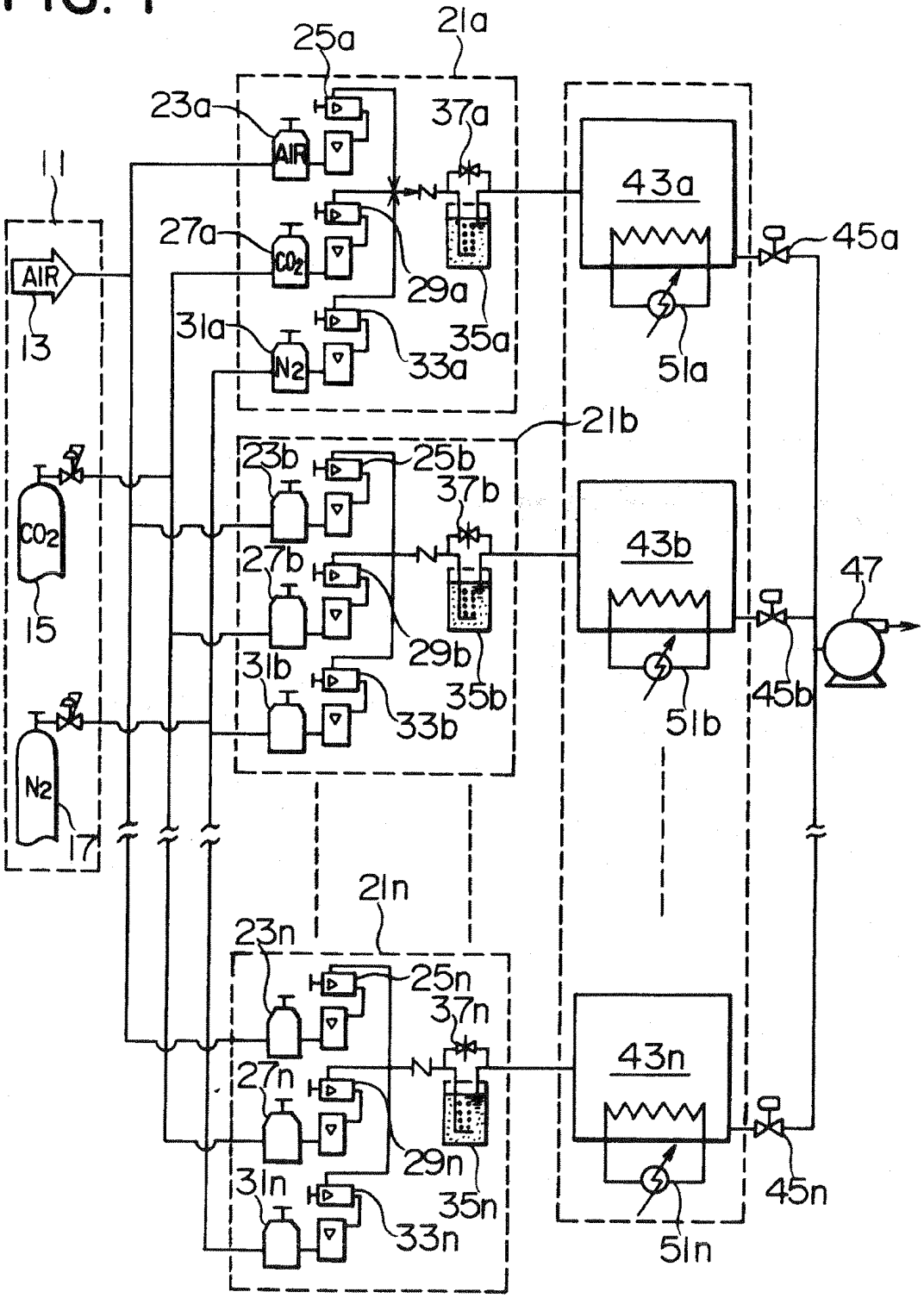
2. Procédé selon la revendication 1 dans lequel de l'air et du dioxyde de carbone de sources externes sont mélangés sous des pressions et des vitesses d'écoulement contrôlées pour préparer un mélange gazeux ayant la même pression et les mêmes teneurs en dioxyde de carbone et en oxygène que lesdites atmosphères contrôlées dans ladite chambre de stockage, et ledit mélange gazeux est alimenté de manière continue à l'intérieur de la chambre de stockage tandis que le gaz équilibré avec la vitesse d'alimentation dudit mélange gazeux est évacué de ladite chambre de stockage.

3. Procédé selon la revendication 1, dans lequel de l'air, du dioxyde de carbone et de l'azote provenant de sources externes sont mélangés sous une pression et des vitesses d'écoulement contrôlées pour

préparer un mélange gazeux ayant la même pression et la même teneur en dioxyde de carbone et en oxygène que lesdites atmosphères contrôlées dans ladite chambre de stockage, et ledit mélange gazeux est alimenté de manière continue dans ladite chambre de stockage tandis que le gaz équilibré avec la vitesse d'alimentation dudit mélange gazeux est évacué de ladite chambre de stockage.

4. Procédé selon la revendication 1, dans lequel une pluralité de chambres de stockage sont prévues, chaque chambre de stockage est reliée à une source externe d'alimentation en gaz commune à toutes les chambres de stockage au travers de moyens de régulation de pression et de composition en gaz et en outre chaque chambre de stockage est aussi reliée avec une pompe à vide commune au travers de vannes de régulation de pressions respectives par lesquelles la pression totale, la pression partielle en oxygène, la pression partielle en dioxyde de carbone et l'humidité relative de chacune des atmosphères contrôlées dans les chambres de stockage respectives sont contrôlées indépendamment des autres chambres de stockage.

FIG. 1


11
AIR
13
CO2
15
N2
17
21a
25a
23a
AIR
37a
27a
CO2
29a
31a
N2
33a
35a
43a
45a
51a
21b
23b
25b
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